THE UNCONFORMITY BETWEEN THE BEDFORD AND BEREA FORMATIONS OF NORTHERN OHIO[1]

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In Lorain County of northern Ohio, 30 to 40 miles west of Cleveland, occurs a striking unconformity between the Bedford and Berea formations. In Ohio the Bedford formation is the lowest member of the Waverly group, Mississippian system. It is an argillaceous shale, the lower portion being a dark bluish gray, the upper portion a chocolate or dark red color. The Berea formation above is a bluish-gray, fine-grained sandstone.

STRUCTURE OF THE BEDFORD AND BEREA FORMATIONS

Dynamic movements of the region have taken place since the laying-down of the Berea sandstone, both formations being uniformly folded. The general structure is that of a syncline whose axis runs northeast and southwest. The red Bedford shale comes to the surface on either side of this trough, which averages about two miles in width. A great deal of the sandstone in the syncline itself has been eroded away, exposing the red Bedford shale beneath. The large rock trough contains minor anticlines and synclines, with axes parallel to that of the large syncline. A compressional force from the east and west has folded the axis of the northeast-southwest syncline into a series of anticlines and synclines. At South Amherst, in the region under discussion, the axis of the large syncline is plunging toward the east.

LENSES OF BEREA SANDSTONE IN THE HORIZON OF THE BEDFORD SHALE

The Bedford forms steep banks where the streams cut against it. As one goes along Beaver Creek, which flows just east of the

[1] The writer wishes to thank Professor G. D. Hubbard, of Oberlin College, for criticism of the manuscript. The work was done in the Department of Geology at Oberlin College.

Berea sandstone quarries at South Amherst, or Chance Creek on the west, he will occasionally find the high banks covered by a mass of Berea sandstone talus. This débris came from a lens of sandstone *in situ* at the top of the bank, extending for 50 to 100 feet on the horizontal, and flanked on either side by red Bedford shale. In places the sandstone is in thin beds 2 to 3 inches thick, at other places in massive beds 3 to 4 feet thick. The lenses range from 10 to 50 feet in total thickness. Their long axes run in a general westward direction. No evidence of slumping is found in connection with the banks at and in the vicinity of these lenses. Neither can they be the bottom of synclinal troughs, for the dips of their minor axes are not great enough to bring the sandstone to the top of the bank of Bedford shale. The only answer to the question of their origin is that there were once channels and depressions in the Bedford shale which, on being filled with sand, ultimately formed (in cross-section) the lenses as they now exist.

So far as the writer is aware, nothing has ever been published regarding this unconformity between the Bedford and Berea formations of northern Ohio, save in the *Ohio Geological Survey Report*, Vol. II, published in 1874. This report mentions lenses in the horizon of the Bedford shale north of Elyria, which is to the eastward of the region under discussion in this article. On p. 91 we read, referring to the erosion of the Bedford prior to the deposition of the Berea: "It is probably due to this fact that the red shale is so frequently found to be wanting in the section."

Mr. H. E. Adams, superintendent of the Ohio quarry at South Amherst, Ohio, states that in the extreme southeast corner of Lorain County, Berea grit occurs in lenses in the horizon of the red Bedford shale exactly in the same manner as at South Amherst.

The Bedford-Berea unconformity is not confined to Lorain County, Ohio. Dr. Hubbard is authority for the statements that "an unconformity occurs at the same horizon in northwestern Fairfield County near Lithopolis; and Professor Prosser believes a similar break exists at the same horizon near Cleveland, Ohio, but further work is there necessary."

The sand-filled troughs in the erosion plane of the Bedford formation which are visible along the streams are small and insig-

nificant in comparison with the channels and valleys whose existence is made known by the drill of the quarry-men.

The deepest of these sand-filled depressions is that in which is located the quarry of the Ohio Stone Company (Fig. 1). This quarry is situated on the outskirts of South Amherst, Lorain

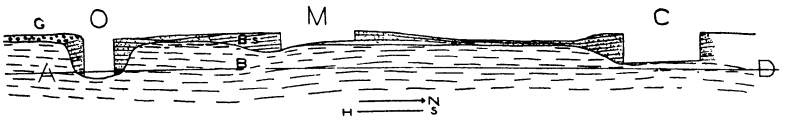

FIG. 1

Horizontal and vertical scale - - - - line H–S = 400 feet. - - - - N = North. Line A–D = elevation of 600 feet above sea-level. B = Bedford shale. Bs = Berea sandstone. G = glacial drift. O = Ohio quarry. M = Malone quarry. C = No. 6 quarry, Cleveland Stone Co.

County, Ohio. The pit has been sunk along the axis of an anticlinal fold which runs in a southwesterly direction. The anticline plunges eastward with a dip of 3°. The south flank of the fold in the quarry has a dip of 6° to the southeast; the north side dips 7° northwest. The great thickness of the sandstone, 217 feet, is due to the sand-filled channel of the eroded Bedford horizon. That this is true is shown by drillings and the structure of the strata in the vicinity. One hundred feet southwest of the edge of the quarry on the same level as the top of the quarry pit, the drill went 60 feet thorugh glacial drift and came upon Bedford shale without encountering any sandstone, and yet the strata in the pit were dipping in that general direction. In the quarry 217 feet of sandstone were passed through before striking Bedford shale. Four hundred feet on the horizontal from the north side of the quarry the strata dip toward the southeast. One thousand feet on the horizontal from this north side of the Ohio quarry, and on the same level as the top of the quarry, another quarry, the Malone, has gone down 100 feet through massive sandstone to the Bedford shale. Here the strata still dip to the southeast; the dip is 7°. Thus a small syncline lies between these two quarries. The dips of the strata are not great enough to carry the sandstone to the depth reached in the Ohio quarry even though the syncline did not exist.

Therefore the Ohio quarry is located in a depression of the eroded horizon of the Bedford shale. The Ohio pit is 175 feet wide, yet neither bank of the Bedford channel in the quarry has been reached.

By drill and well records, the writer has traced this channel, in which is the Ohio quarry, for a distance of three and one-half miles to the southwestward where it outcrops on the steep valley slopes of a stream known as Chance Creek. Here the lens of sandstone is 50 feet wide and 15 feet thick. On both sides and at the bottom the sandstone lies directly against the red Bedford shale. The decreasing of the channel in depth and width as it went southwestward indicates that the stream flowed from the southwest toward the east.

Beaver Creek flows a little less than one-half mile east of the Malone quarry. Here no sandstone is found along the banks, in spite of the fact that the axis of the anticline is plunging in that direction at an angle of 3°. The outcrops of Bedford shale at this place on the creek are 30 to 40 feet lower in elevation than the top of the sandstone at the Malone quarry, where the sandstone is 100 feet thick. Still, if the Malone quarry deposit of Berea grit is not a sandstone-filled depression in the Bedford shale, the sandstone should outcrop at Beaver Creek, which it does not do. This quarry therefore also is located in a lens of sandstone in the horizon of the Bedford shale.

A short distance farther north of the Malone quarry is No. 6 quarry of the Cleveland Stone Company. Structurally this quarry is on the southward-dipping flank of an anticline whose axis runs in a southwesterly direction. The average dip is 8°. The axis itself is folded into a low, small anticline in the west portion of the quarry. Here, as elsewhere in the region, the sudden great thickness of sandstone cannot be accounted for save as a sand-filled channel of the eroded horizon of the Bedford shale. Although the long axis of No. 6 quarry does not exactly coincide with the direction of the channel in which it is located, yet, both being in nearly the same westerly direction, the size of the pit gives some idea as to the size of the valley in the Bedford formation. The quarry is 2,632 feet long, has an average width of 460 feet, and a depth of from 100 to 175 feet.

BLUE SHALE AT THE UNCONFORMITY

In the bottom of all these deep channels in the horizon of the red Bedford shale is a soft, dark-blue shale, three to four feet thick. This blue shale is not found beneath the sandstone of the small lenses in the Bedford horizon, nor is it found at any given horizon. The bottoms of the quarries are at different depths with the dip of the strata too slight to bring this blue shale to all the quarry floors. The outcrop of the Ohio quarry channel on Chance Creek had no blue shale beneath the sandstone, the sandstone resting directly upon red Bedford shale. Yet this blue shale is found underlying the sandstone in the Ohio pit.

The reason for the location of this blue shale may be the following: The lower and deeper portions of the valleys of the Bedford streams became drowned. Sediment carried by the rivers into these quiet bodies of water was deposited and eventually formed this blue shale which occurs between the red Bedford shale and the Berea sandstone.

Dr. Hubbard and the writer made a careful search for fossils in this blue shale, but none were found.

CONCLUSION

Starting a few miles east of Sandusky, Ohio, and extending eastward to Cleveland, Ohio, there is a well-defined unconformity between the Bedford and Berea formations. The unconformity, however, extends over a greater area than the region above defined, as it has been noted as far south as Fairfield County, Ohio.

During the period that the Bedford horizon was above the level of the sea, its surface was dissected, streams cutting deep channels and wide valleys. The lower portions of these valleys became drowned. In the quiet water thus formed, the rivers deposited sediment which later became a blue shale, logically belonging to the Berea formation.

The entire Bedford land area gradually was submerged, and the Berea sandstone formation was laid down.